PATENT SPECIFICATION

783,881

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COMPLETE SPECIFICATION

Improvements relating to Shaft and like Seals

We, METROPOLITAN-VICKERS ELECTRICAL COMPANY LIMITED, of St. Paul's Corner, 1—3 St. Paul's Churchyard, London, E.C.4, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the sealing against leakage of associated fluids, of relatively movable parts, such as shafts and the like, when a pressure gradient exists for causing such leakage.

Mechanical arrangements for the sealing of such relatively movable parts are well known. It is usual for such seals to comprise one or more flexible sealing washers made from rubber or similar material, the spaces between adjacent washers being partially evacuated or pressurised if desired.

It has, however, been proposed to provide a seal between relatively movable parts embodying a magnetic element secured to one of the parts and a fluid containing magnetic particles, said fluid being subjected to the magnetic field of the magnetic element and thereby solidified to form a seal between said parts.

The object of the present invention is to provide an improved seal between relatively movable parts.

According to the present invention a seal between relatively movable parts comprises a magnetic element attached to one of such parts, the poles of said element, or pole pieces attached thereto, being spaced apart to form a gap therebetween and extending to within a short distance of the other part which latter is of magnetic material or incorporates a member of such material so as to constitute a portion of the magnetic circuit between the poles or pole pieces, the spaces between the poles, or pole pieces and the said other part, but not the aforesaid gap, being bridged by a magnetic fluid comprising finely divided materials together with a grease or oil, at least one constituent of the finely divided material being in the form of magnetic particles so that the fluid is pulled into said spaces and kept rigid by the magnetic field between the poles, or pole pieces and the said other part to form two annular seals with gap therebetween.

This invention will be better understood from the following description of the drawings filed with the Provisional Specification, in which Fig. 1 shows in cross-section a part of a steel shaft provided with magnetic sealing in accordance with the invention; Fig. 2 shows in detail three of the many different shapes which may be adopted for the pole pieces of the magnetic circuit; Fig. 3 is a view similar to Fig. 1 of a modification, and Figs. 4, 5, 6 and 7 are detail views of further alternative constructions.

It should be noted that although these examples refer to rotatable shafts and tubes, the invention is not so limited, being applicable also to sliding, oscillating or reciprocating shafts or members of any cross sectional shape or to a continuously moving member being fed through the seal.

Fig. 1 shows a shaft of magnetic material 1, rotatable inside a housing 2 and separated therefrom by the bearing 3. Such an arrangement may constitute part of a vacuum assembly, in which case the interior 4 will be at a lower pressure than the exterior 5. Alternatively it may constitute part of a turbine assembly in which case 4 will be at a higher pressure than 5. An annular permanent magnet 6 made, for example from the material known by the registered Trade Mark Alcomax and magnetised axially, is attached to the non-magnetic bearing housing 7. Annular mild steel pole pieces 8, 9 are disposed substantially coaxially with the rotatable shaft 1, the magnitude of the separation between the pole pieces and the shaft being of the order of a few thousandths of an inch. These gaps are sealed by means of a fluid comprising a finely divided magnetic powder suspended in a viscous liquid, e.g., the fluid described in our Co-pending Application No. 22879/53

[Price

Patent No. 756,563. Such a fluid is pulled into the gaps and kept rigid by means of the radial magnetic field between the pole pieces and the shaft, so preventing diffusion of gas from 4 to 5 or *vice versa*. At the same time, the nature of the fluid provides a low friction contact between the sealing element and the relatively moving part. It will, of course, be necessary to prevent any leakage of gas via alternative routes and gaskets 10, 11 and 12 made from any suitable material, e.g., rubber, polythene, lead, etc., are incorporated in the assembly.

The permanent magnet may be replaced by an electromagnet, but since this would have to be kept permanently energised to prevent the sealing fluid from escaping, in general, this would not be very convenient.

The pole pieces are preferably shaped to provide a magnetic field, the strength of which decreases as the distance from the centre line of the pole piece increases. Thus, referring to the construction shown in Fig. 2, at (*a*) the pole piece is bevelled to provide the desired concentration of the field. Such a non-uniform field exerts a force on the magnetic particles of the fluid, tending to urge them axially towards the centre line, so minimising the possibility of any of the fluid escaping. By fitting a shaped collar 8^1 to the shaft as shown at (*b*), the magnetic field may be concentrated still more, thereby producing a greater axial force on the fluid particles. At (*c*) is shown a further alternative in which the length of the leakage path is greatly increased by making the pole piece with a peripheral slot the sides of which embrace the collar 8^1. With a rotating shaft the peripheral slot construction can be arranged to combine the centrifugal force on the sealing fluid and the magnetic force to improve the efficiency of the seal.

As mentioned above, it is well known to use a graded pressure drop in the form of two sealing washers the space between which is maintained at a pressure intermediate between the internal and external pressures concerned. Fig. 3 shows how the present invention can be adapted to incorporate a graded pressure drop by modifying the construction shown in Fig. 1. In this modified construction, two magnetic sealing units 14, 15, are employed, these being separated by a space 16 which is maintained at a pressure intermediate between that against which the seal is to be effective. Thus the space 16 may be maintained at a partial vacuum, or be partially pressurised, via the tube 17, depending on the particular use to which the seal is being put. By this arrangement, the total pressure drop is obtained in two stages, so reducing the pressure drop which each seal need stand up to and thus reducing the possibility of gas leakage.

A modification of the arrangement of Fig. 3 is shown in Fig. 4. In this case, only one magnetic unit is required, the magnet being cast with a hole 18 through it, so that the space between the poles 19 and 20 can be evacuated or pressurised as required.

Fig. 6 shows a further modification proposed for use in cases where it is absolutely essential that no leakage should occur as, for example, if the apparatus contains highly radioactive gas. This modification merely comprises arranging a plurality of magnetic units each consisting of a permanent magnet and its associated pole pieces in succession so as to form a plurality of air gaps in series filled with magnetic fluid, so increasing the number of "barriers" which the gas must pass before escaping. The modification of Fig. 4 could be applied to this arrangement so that each or any of the spaces between the pole pieces may be pressurised as desired.

Fig. 6 shows how the method may be adapted to provide a seal between relatively rotatable tubes 21 and 22, there being a pressure difference between the inside and the outside of the tube. In this arrangement the tubes are flanged at 23, 24, and the annular magnet is provided with pole pieces in the form of flanged rings 25, 26.

It is not essential that the magnetic element should be annular, and applications are envisaged where a flat plate of magnetic material would be advantageous. For example, Fig. 7 shows a magnet plate 28 clamped between semi-circular mild steel pole pieces 29, 30, through which a rotatable shaft 31 may pass. With this arrangement, it would be possible to provide a transparent cover to enable experiments in evacuated (or pressurised) conditions to be watched.

It will be obvious that the magnetic element may be secured to the movable member instead of the stationary member without departing from the invention.

Although in the above examples at least one of the members is made of magnetic material, the invention may readily be adapted for use when both members are non-magnetic, e.g. stainless steel, brass and the like. For the above arrangements to be applied, a magnetic, e.g. mild steel, section may be inserted in or shrunk on to the main shaft at the seal.

While the description of the embodiments of the invention hereinbefore referred to has been particularly directed towards the sealing against gaseous leakage of the space between relatively movable parts, effective sealing is also obtained against leakage of liquids that are not solvents of the grease or oil constituent of the magnetic fluid.

What we claim is:—

1. A seal between relatively movable parts comprising a magnetic element attached to one of such parts, the poles of said element, or pole pieces attached thereto being spaced apart to form a gap therebetween and extending to

within a short distance of the other part which latter is of magnetic material or incorporates a member of such material so as to constitute a portion of the magnetic circuit between the poles or pole pieces, the spaces between the poles, or pole pieces and the said other part but not the aforesaid gap, being bridged by a magnetic fluid comprising finely divided materials together with a grease or oil, at least one constituent of the finely divided material being in the form of magnetic particles so that the fluid is pulled into said spaces and kept rigid by the magnetic field between the poles, or pole pieces and the said other part to form two annular seals with gap therebetween.

2. A seal between relatively movable parts comprising a plurality of seals as claimed in Claim 1 arranged in succession.

3. A seal as claimed in Claim 2, wherein the space between each seal is maintained at a pressure intermediate between that against which the seal is to be effective.

4. A seal as claimed in any preceding Claim, in which the pole pieces are shaped to provide a magnetic field the strength of which varies with the distance from the centre line of the pole piece.

5. A seal as claimed in any preceding Claim and adapted for application to relatively rotatable parts, wherein the magnetic element is in the form of an annular permanent magnet axially magnetized with annular collars disposed on each side thereof to form the pole pieces.

6. A seal as claimed in any of Claims 1 to 3, and adapted for application to relatively rotatable parts, in which at least one pole piece is provided with a peripheral slot into which enters a collar projecting from said other part.

7. Seals between relatively movable parts constructed substantially as described with reference to the drawings filed with the Provisional Specification.

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Chartered Patent Agent,
64—66, Coleman Street, London, E.C.2,
Agent for the Applicants.

PROVISIONAL SPECIFICATION

Improvements relating to Shaft and like Seals

We, METROPOLITAN-VICKERS ELECTRICAL COMPANY LIMITED, of St. Paul's Corner, 1—3 St. Paul's Churchyard, London, E.C.4, a British Company, do hereby declare this invention to be described in the following statement:—

This invention relates to the sealing, against leakage of associated fluids, of relatively movable parts, such as shafts and the like, when a pressure gradient exists for causing such leakage.

Mechanical arrangements for the sealing of such relatively movable parts, are well known. It is usual for such seals to comprise one or more flexible sealing washers made from rubber or similar material, the spaces between adjacent washers being partially evacuated or pressurised if desired.

The object of the present invention is to provide a novel type of seal in which wear of the sealing glands is avoided.

According to the invention a seal between relatively movable parts comprises a magnetic element attached to one of said parts and provided with pole pieces extending to within a short distance of the other of said parts, the space between the pole pieces and the second of the said parts forming, or being in proximity to the, or part of the, air gap of the magnetic circuit and being filled with a magnetic fluid comprising finely divided materials together with a grease or oil at least one constituent of the finely divided material being in the form of magnetic particles.

This invention will be better understood from the following description of the accompanying drawings, in which Fig. 1 shows in cross-section a part of a steel shaft provided with magnetic sealing in accordance with the invention. Fig. 2 shows in detail three of the many different shapes which may be adopted for the pole pieces of the magnetic circuit; Fig. 3 is a view similar to Fig. 1 of a modification; Figs. 4, 5, 6 and 7 are detail views, of further alternative construction.

It should be noted that although these examples refer to rotatable shafts and tubes, the invention is not so limited, being applicable also to sliding, oscillating or reciprocating shafts or members of any cross sectional shape or to a continuously moving member being fed through the seal.

Fig. 1 shows a magnetic shaft 1 rotatable inside a housing 2 and separated therefrom by the bearing 3. Such an arrangement may constitute part of a vacuum assembly, in which case the interior 4 will be at a lower pressure than the exterior 5; Alternatively it may constitute part of a turbine assembly in which case 4 will be at a higher pressure than 5. (The invention will also serve as a water or oil-seal). An annular permanent magnet 6 made, for example from the material known by the Registered Trade Mark Alcomax and magnetised axially, is attached to the non-magnetic bearing housing 7. Annular mild steel pole pieces 8, 9 are disposed substantially coaxially with the rotatable shaft 1, the magnitude of the separation between the pole pieces and the shaft being of the order of a few thousandths of an inch. These gaps are sealed by means of a fluid comprising a finely

divided magnetic powder suspended in a viscous liquid, e.g., the fluid described in our Copending Application No. 22879/53 Patent No. 756,563. Such a fluid is pulled into the gaps and kept rigid by means of the radial magnetic field between the pole pieces and the shaft, so preventing diffusion of gas from 4 to 5 or vice versa. At the same time, the nature of the fluid provides a low friction contact between the sealing element and the relatively moving part. It will, of course, be necessary to prevent any leakage of gas via alternative routes and gaskets 10, 11 and 12 made from any suitable material, e.g., rubber, polythene, lead, etc., are incorporated in the assembly.

The permanent magnet may be replaced by an electromagnet, since this would have to be kept permanently energised to prevent the sealing fluid from escaping, in general, this would not be very convenient.

The pole pieces are preferably shaped to provide a magnetic field, the strength of which decreases as the distance from the centre line of the pole piece increases. Thus, referring to the construction shown in Fig. 2, at (*a*) the pole piece is bevelled to provide the desired concentration of the field. Such a non-uniform field exerts a force on the magnetic particles of the fluid, tending to urge them axially towards the centre line, so minimising the possibility of any of the fluid escaping. By fitting a shaped collar 8^1 to the shaft as shown at (*b*), the magnetic field may be concentrated still more, thereby producing a greater axial force on the fluid particles. At (*c*) is shown a further alternative in which the length of the leakage path is greatly increased by making the pole piece with a peripheral slot the sides of which embrace the collar 8^1. With a rotating shaft the peripheral slot construction can be arranged to combine the centrifugal force on the sealing fluid and the magnetic force to improve the efficiency of the seal.

As mentioned above, it is well known to use two sealing washers and to maintain the space between the two washers at a pressure intermediate between the internal and external pressures concerned. Fig. 3 shows how the present invention can be adapted to incorporate this improvement by modifying the construction shown in Fig. 1. In this modified construction, two magnetic sealing units 14, 15, are employed, these being separated by a space 16 which may be maintained at a partial vacuum or partially pressurised via the tube 17, depending on the particular use to which the seal is being put. By this arrangement, the total pressure drop is obtained in two stages, so reducing the pressure drop which each seal need stand up to and thus reducing the possibility of gas leakage.

A modification of the arrangement of Fig. 3 is shown in Fig. 4. In this case, only one magnetic unit is required, the magnet being cast with a hole 18 through it, so that the space between the poles 19 and 20 can be evacuated or pressurised as required.

Fig. 5 shows a further modification proposed for use in cases where it is absolutely essential that no leakage should occur as, for example, if the apparatus contains highly radioactive gas. This modification merely comprises assembling a number of magnetic units in series so increasing the number of "barriers" which the gas must pass before escaping. The modification of Fig. 4 could be applied to this arrangement so that each or any of the spaces between the pole pieces may be pressurised as desired.

Fig. 6 shows how the method may be adapted to provide a seal between relatively rotatable tubes 21 and 22, there being a pressure difference between the inside and the outside of the tube. In this arrangement the tubes are flanged at 23, 24 and the annular magnet is provided with pole pieces in the form of flanged rings 25, 26.

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It will be obvious that the magnetic element may be secured to the movable member instead of the stationary member without departing from the invention.

Although in the above examples at least one of the members is made of magnetic material, the invention may readily be adapted for use when both members are non-magnetic, e.g. stainless steel, brass and the like. For the above arrangements to be applied, a magnetic, e.g. mild steel, section may be inserted in or shrunk on to the main shaft at the seal.

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Agent for the Applicants.

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Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

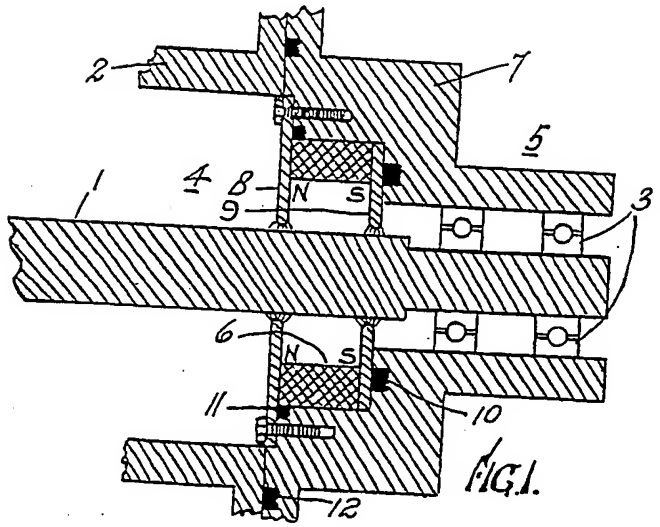

FIG.1.

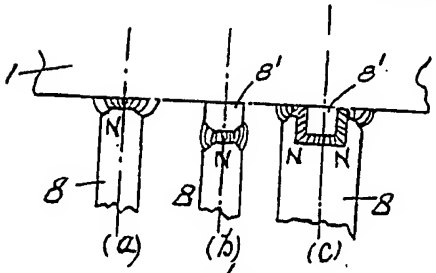

FIG.2.

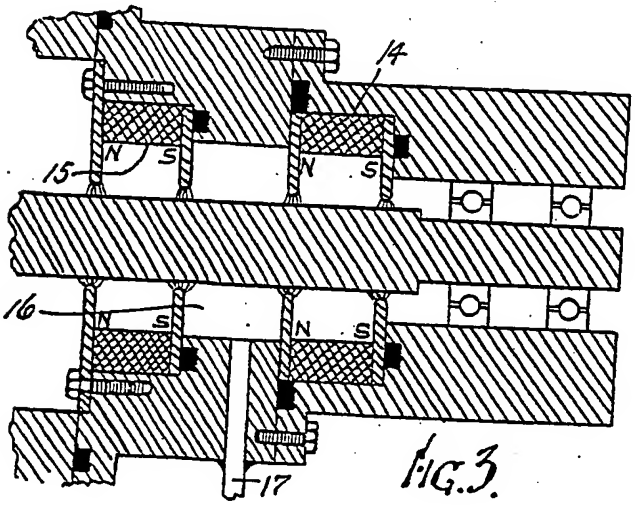

FIG.3.

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2 SHEETS

PROVISIONAL SPECIFICATION

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Sheets 1 & 2

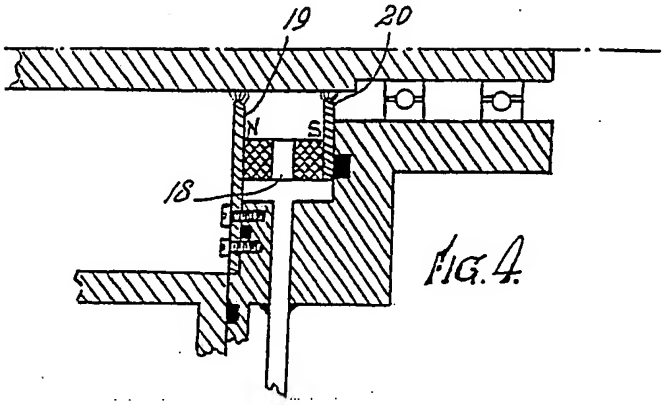

FIG.4.

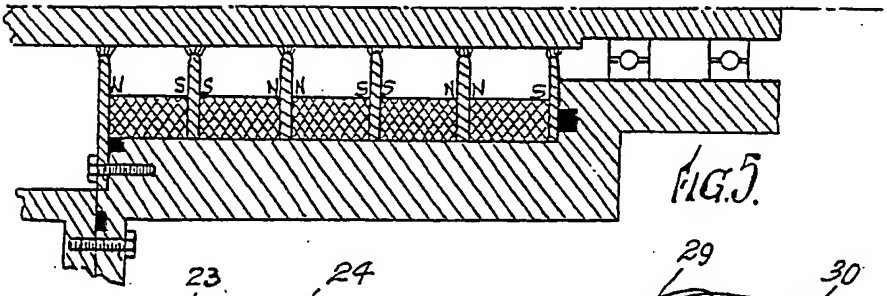

FIG.5.

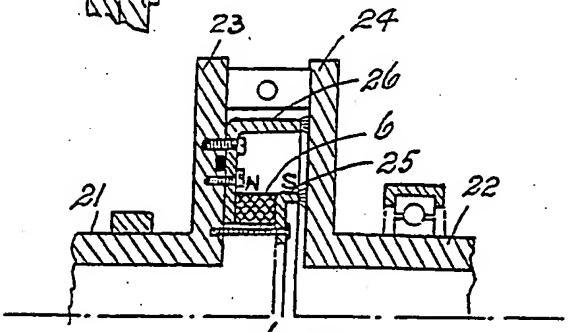

FIG.6.

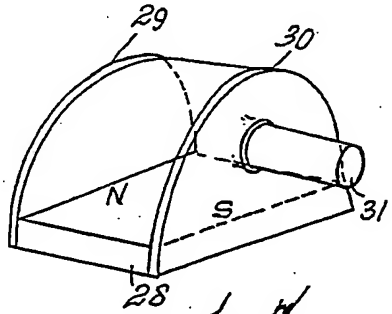

FIG.7.

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2 SHEETS

PROVISIONAL SPECIFICATION
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Sheets 1 & 2

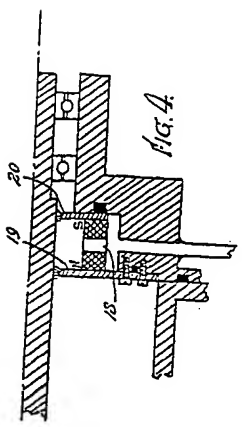

FIG. 4.

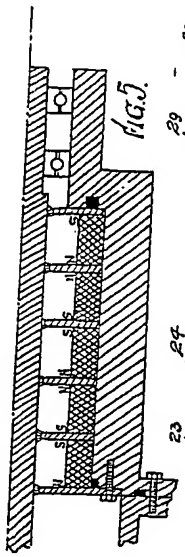

FIG. 5.

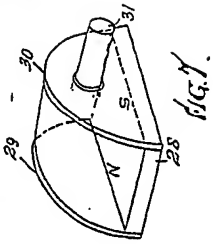

FIG. 7.

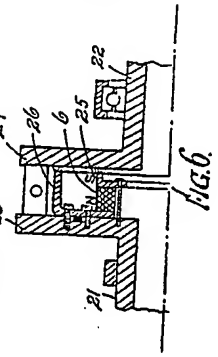

FIG. 6.

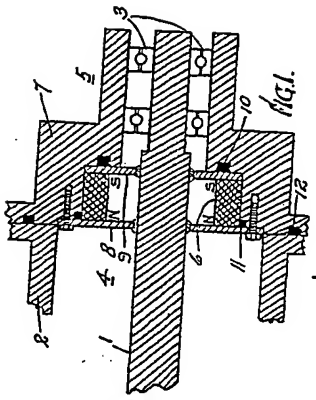

FIG. 1.

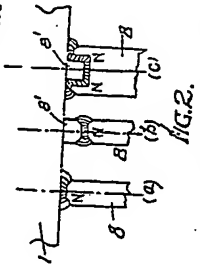

FIG. 2.

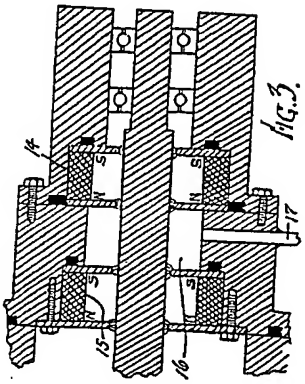

FIG. 3.